3. Notes on the Visceral Anatomy of Birds.—No. II. On the Respiratory Organs in certain Diving Birds. By Frank E. Beddard, M.A., F.R.S.E., Prosector to the Society.

[Received May 1, 1888.]

This note is based on the examination of some Puffins (*Fratercula arctica*) and of examples of two species of Penguins (*Eudyptula minor* and *Spheniscus demersus*), all of which have come into my hands for dissection at the Society's Gardens.

The most noticeable peculiarity about the respiratory apparatus of *Fratercula*, indeed the only one that I observed, concerns the structure of the oblique septum ("*diaphragm thoraco-abdominale*," Sappey); the general relations of this fibrous septum, which shuts off the lungs and the 'intermediate' air-sacs from the abdominal cavity, have been already described in the 'Proceedings' of this Society [1] by Prof. Huxley; as that description applies perfectly to the three birds treated of in the present note, I merely refer to it. I may mention, however, that the best figure known to me illustrating the general disposition of the thoracic and abdominal viscera of a bird is to be found in Wiedersheim's 'Lehrbuch der vergleichenden Anatomie der Wirbelthiere' [2]. *The oblique septum of* Fratercula *is remarkable for the fact that it is covered for a considerable area with a layer of muscular fibres.* This layer of muscular fibres arises (fig. 1, p. 253) from the pubis—from the proximal and larger half of this bone; it is abundantly furnished with blood-vessels and nerves. The direction of the muscle is oblique; it covers the hinder region of the oblique septum, ending abruptly some little way in front of the posterior attachment of the latter; the oblique septum, as in other birds, arises partly from the pubis, but the posterior limit of its attachment to this bone is considerably further forward than that of the sheet of muscle. This sheet of muscle, besides ending abruptly upon the oblique septum in front, is attached below to the upper surface of the sternum, and to the abdominal parietes along the last sternal rib. On the left side of the body the sheet of muscles is attached to the sternum along a line much closer to the attachment of the umbilical ligament than on the right side. The muscular fibres which make up the sheet of muscle are arranged in a parallel series of comparatively thick bundles with transparent (? fibrous) interspaces.

The presence of this muscular layer is not, however, peculiar to the Puffin.

Prof. Huxley, in the paper already quoted, states that in the Duck the oblique septum "contains, on each side, a layer of unstriped muscular fibres." Judging from Prof. Huxley's figure (*op. cit.* p. 565, fig. 2, *m*), the layer of muscular fibres in the Duck is by no means so extensive as in the Puffin. Prof. Huxley particularly states that he has been unable to discover any such fibres in *Apteryx*.

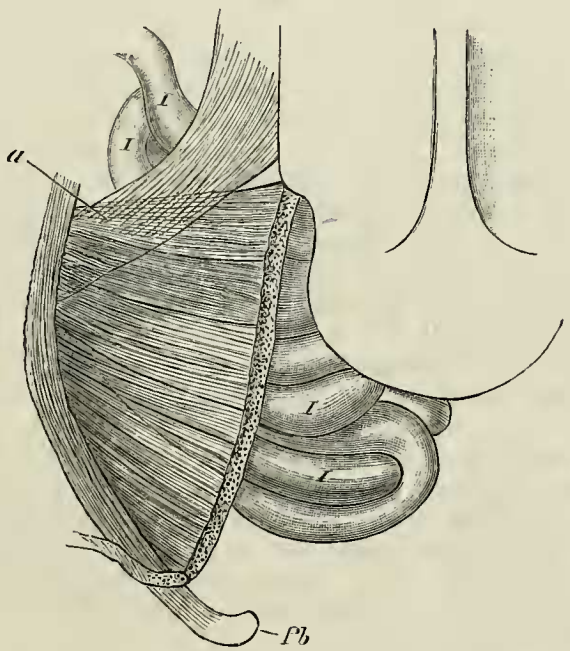
[1] P. Z. S. 1882, p. 560. [2] 2te Aufl., Jena, 1886, p. 654.

In the very complete description of the respiratory apparatus of birds which Prof. Wiedersheim gives in his 'Lehrbuch der vergleichenden Anatomie' there is no mention of any other bird in which muscular fibres cover the oblique septum; Prof. Huxley's statement about the Duck is referred to in a footnote [1].

I have found that an identical structure occurs in two species of Penguin, viz. *Eudyptula minor* and *Spheniscus demersus*; in both of these birds the oblique septum is covered posteriorly by a layer of muscular fibres which rise from the pubis and are attached ventrally to the sternum.

After referring to the late Prof. Morrison Watson's elaborate

Fig. 1.



Dissection of *Fratercula arctica*, to illustrate disposition of oblique septum.
a, oblique septum; *I*, coils of intestine; *Pb*, pubis.

and well-illustrated Report upon the Penguins collected by the 'Challenger' [2], and finding there no mention of this muscular layer, I believed that this particular resemblance between the Puffin and the Penguins would be recorded for the first time in the present paper. Quite recently I have become acquainted with the contents of a short paper [3] by M. Filhol, in which he describes this muscular layer in the Penguin, though in another species. The following

[1] P. 665, note 2.
[2] Zool. Chall. Exp. vol. vii.
[3] "Sur la constitution du diaphragme des *Eudyptes*," Bull. Soc. Philom. (7) t. vi. p. 235.

quotation from his paper will show that he probably refers to a structure identical with that described in the present note (*loc. cit.* p. 236):—

"Indépendamment de ces deux faisceaux musculaires que l'on retrouve avec la même disposition chez tous les oiseaux, j'ai observé chez les *Eudyptes* au niveau de l'ongle formé en dehors par le diaphragme thoraco-abdominale et la portion inférieure du diaphragme thoracique, un faisceau musculaire à fibres pâles et divergentes. Ces fibres sont dirigées suivant le contour qu'affecte en leur point d'existence la cavité abdominale. Elles sont assez courtes et se terminent toutes par un sommet aponeurotique. Je désignerai ce muscle par l'appellation de muscle diaphragmatique transverse."

It appears therefore that the Puffins as well as the Penguins and Ducks are to be distinguished from many other birds by the fact that the oblique septum is partially covered by a layer of muscular fibres. But this layer of muscular fibres is by no means equally developed in all the three groups of birds. It is best developed in the Puffin and in the Penguins; it appears to be very feebly developed in the Duck. Prof. Huxley gives no particular description of it in the Duck, but his figure [1] shows that the layer of muscular fibres is very limited in extent and does not reach nearly as far as the sternum. It is attached to the dorsal middle line of the body and only covers the oblique septum for a very short way. I have found in the Toucan (*Rhamphastos ariel*) a perfectly similar patch of muscle occupying an identical position; the muscular fibres in this case also were obviously unstriated.

There is another important difference between the muscular layer of the oblique septum in the Duck and that in the Puffin. *The fibres are in the Duck (according to Prof. Huxley) and in the Toucan unstriated; in the Puffin they are distinctly striated*: I unfortunately neglected to observe whether this was also the case in the Penguins, and Filhol makes no mention of the point.

It does not, however, as it appears to me, affect the question of the homology of the muscular layer covering the oblique septum in these three types to learn that the fibres are striate in the one and unstriate in the other.

The muscular fibres of the alimentary tract are commonly said to be striated in the Tench, while they are unstriated in other fish. It is unnecessary to insist upon the homology of the muscular layer in the two cases.

Mr. C. F. Marshall, in a paper upon the histology of muscle [2], points out that striation in the fibres of muscle-bundles appears to be associated with greater activity on the part of the muscle. The muscles, for example, of an *Echinus* are for the most part unstriated; those muscles which move the valves of the pedicellariæ are striated, as was shown by Mr. Geddes and myself, and more recently by Hamann. The pedicellariæ are undoubtedly the most actively moving organs of the *Echinus*; and the nature of their muscles (striate) supports the views of Mr. Marshall.

[1] *Loc. cit.* p. 565, fig. 2, *m*. [2] Quart. Journ. Micr. Sci., Aug. 1887.

It is possible then, as it appears to me, that the feebly developed muscular layer which extends for a short way over the dorsal attachment of the oblique septum in the Duck and in the Toucan may be the degenerate rudiment of the powerful muscle which extends over so large a portion of the oblique septum in the Penguin and in the Puffin. There is nothing, moreover, in the facts, so far as they have been stated, to disprove the truth of the converse to the above, viz. that the powerfully developed muscular layer of the Penguin and the Puffin is a further development of the feeble musculature of the oblique septum in the Duck.

To decide which of these two alternatives is the more probable, it is necessary to go into the question of the nature and homologies of the muscular layer in question.

I have at present been unable to discover any bird in which the oblique septum showed characters which would serve to throw any light upon the question.

No doubt the structure of the viscera of the extinct Dinosauria would solve the problem at once; but, failing these, it is clear that the Crocodilia more than any existing group of Reptiles approach birds in their structure.

Prof. Huxley has in his paper, so frequently referred to, indicated many striking resemblances between the respiratory organs of Birds and those of Crocodiles.

It had already been noted by Sir R. Owen[1] and by Dr. Martin[2] that the abdominal cavity of Crocodiles is remarkable for the great development of special serous sacs enveloping the various viscera, its cavity being thus greatly subdivided. In this arrangement there is a very close similarity to Birds, as Prof. Huxley pointed out. "A fibrous expansion extends from the vertebral column over the anterior face of the stomach, the liver, and the dorsal and front aspect of the pericardium, to the sternum and the parietes of the thorax, separating the thoraco-abdominal space into a respiratory and a cardio-abdominal cavity, and representing the oblique septum of the bird" (Huxley, *loc. cit.* p. 568). This supposed homologue of the oblique septum in the Crocodile is not, however, simply made up of a layer of fibrous tissue; Prof. Huxley goes on to say in the same paper and on the same page :—"A broad, thin muscle arises, on each side, from the anterior margin of the pubis; and its fibres pass forwards, diverging as they go, to be inserted into the ventral face of the posterior part of the pericardium and into the ventral and lateral parts of the fibrous capsule of the stomach, passing between that organ and the adherent posterior face of the liver, and being inserted into the fibrous aponeurosis which covers the anterior surface of the stomach, and represents the oblique septum."

If the homologies instituted by Prof. Huxley be allowed, then *this muscle is clearly the equivalent of the muscle which I have described in this paper in the Puffin* and which M. Filhol has described in the Penguin; in every case the muscle arises from the pubis and extends as far as the region of the stomach; in the two birds,

[1] P. Z. S. 1831, p. 139. [2] P. Z. S. 1835, p. 129.

however, the muscle is attached to the sternum and its fibres are striated (? Penguin); as to the Crocodile, Prof. Huxley does not state whether the muscles are striated or not. Judging from the analogy of other reptiles (Lacertilia), where muscular fibres also extend into the mesenteries [1], they are not; but the homology is not, in my opinion, already stated, affected by this question [2].

The rudimentary muscles which clothe a limited area of the oblique septum in the Duck and Toucan are probably to be derived from the same muscle in the Crocodile, or else they may be directly traceable to a bird ancestor in which the same muscles were present in the same hypertrophied condition that they now are in the Penguin and Puffin.

The muscle in question is in fact more highly developed in the Puffin and Penguin than in the Crocodile; but the habits of the birds suggest an explanation not only of the retention of the muscle but also of its great development and the appearance of an attachment to the ventral parietes.

Both these birds are diving birds, and it seems therefore reasonable to suppose that any organ which would facilitate vigorous inspirations and expirations would be highly advantageous. Now the respiratory movements in birds are largely brought about by the abdominal muscles, which depress the sternum and the parietes, and so drive the air from the air-sacs through the lungs to the exterior. But the sternum in the Puffin &c. is long and the muscular abdominal parietes are therefore shorter than usual. The muscular force available is as a consequence not so great as in many other birds (*e. g.* the Emu); this deficiency is made up for by the muscle covering the oblique septum, and moreover the relations of this muscle are such that it is particularly available for its presumed function.

In the first of the present series of "Notes upon the Visceral Anatomy of Birds" [3] I have called attention to the resemblance between the so-called "omentum" of Birds and the "horizontal septum" of the Crocodile, which is directly continuous with the oblique septa of the same reptile, and is apparently not distinguished from it by Prof. Huxley. It seems to me that *the entire fibrous expansion which arises from the vertebral column and extends over the anterior face of the stomach, liver, &c. in the Crocodile represents both the oblique septa and the omentum in the bird.*

The middle part of the fibrous expansion in the Crocodile bears the two anterior abdominal veins, or at least they pass between it and the ventral parietes. In the bird there are a number of small veins upon the omentum which join the portal system, and are probably collectively the equivalents of the anterior abdominal system in the Crocodile. This appears to me to be an argument in favour of identifying the median portion of the fibrous expansion in the Crocodile with the omentum of the bird.

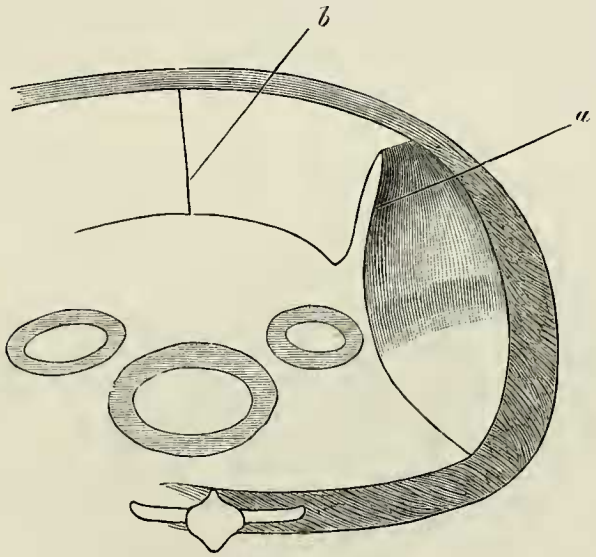
[1] Rathke, Wiener Sitzungsb. 1852.

[2] Prof. G. B. Howes tells me that the muscle in question is composed of plain fibres in the Crocodile.

[3] P. Z. S. 1885, p. 836.

A difficulty in the way of this comparison is the relation of the omentum to the oblique septa in many birds; the oblique septa pass from the hinder part of the abdominal cavity arising from, or near, the pubis; they are attached to the parietes ventrally and dorsally, and completely shut off a triangular segment of the cœlom from that portion of the cœlom which contains the intestines; the omentum comes into contact with the oblique septum and even fuses with it, but it is quite distinct from it, in the direction of its fibres, &c. It

Fig. 2.



Diagrammatic transverse section through abdominal region of Emu, to illustrate the oblique septum.

a, oblique septum; *b*, umbilical ligament.

might appear therefore at first sight as if the omentum was a structure peculiar to birds and that the whole of the "fibrous expansion" of the Crocodile represented the oblique septa, the only difference being that in the birds the two halves had shrunk away from each other towards the lateral parietes.

The relation of the oblique septa to the omentum in the Emu is rather different from that of many birds and enables this difficulty to be surmounted. The oblique septa pass back to the extremity of the abdominal cavity, but posteriorly they are not attached to the ventral parietes; the oblique septum has thus a free ventral edge for a considerable length; the omentum is attached to it apparently as in other birds, but on stretching the oblique septum the free edge is seen to be double and really to be produced by an upward fold; at this point the strong interlacing tendinous fibres of the oblique septum disappear and the membrane passes without any break into the omentum. If this membrane is sufficiently stretched

the intestines of the Emu are seen to be covered by a horizontal septum, which resembles that of the Crocodiles except that it does not arise from the dorsal median line but along two lines placed nearer to the lateral parietes; the relations of the posterior region of the oblique septum to the omentum are represented diagrammatically in the accompanying drawing (fig. 2, p. 257). These facts, then, support my contention that *the omentum as well as the oblique septa of birds are to be derived from the fibrous expansion which covers over the viscera in the Crocodilia.*

They also suggest that *the oblique septum of birds has been produced by a vertical fold of this fibrous expansion* which became attached to the ventral parietes and ultimately lost all traces in most birds (?) of its primitively double nature, and not by a separation of part of it.

4. Observations on the Fishes of India.—Part I.

By Francis Day, C.I.E., F.Z.S.

[Received April 13, 1888.]

During the ten years that have elapsed since the completion of my work upon the 'Fishes of India,' several new piscine forms have been obtained, both from the seas and fresh waters of that part of Asia. Extended observations among specimens preserved in the Museums of Europe have likewise convinced me that some species which I formerly considered to be undescribed have no title to that designation, while several of my new ones have been redescribed as novelties by others. The foregoing reasons would scarcely have induced me to recur again to this interesting fish-fauna had it not been that it is proposed to re-issue my work in a more portable size, better suited to the requirements of travellers and collectors. As the subject of the geographical distribution of these fishes will have to be considered, I am obliged to point out not only such forms as I have erroneously described to be new, but likewise to advert to those of other describers which I believe would come under this head.

Cromileptes altivelis.

Serranus altivelis, Cuv. & Val.

? *Serranus striolatus*, Playfair, Fish. Zanzibar, p. 11, pl. iii. f. 2.

? *Serranus gibbosus*, Boulenger, P. Z. S. 1887, p. 654.

The figure of *Serranus altivelis* in Cuv. & Val. ii. pl. xxxv. shows the spines of the dorsal fin increasing in length to the last, which is delineated nearly twice as long as the second. Cantor, in his 'Malayan Fishes,' remarked that these spines from the third were of nearly equal length; Bleeker shows them slightly, but gradually augmenting to the last, which is figured as one fifth longer than the third: I have observed them more nearly corresponding with Cantor's description. The foregoing shows that differences do exist as to the length of these spines, and that a gradual augmentation from the